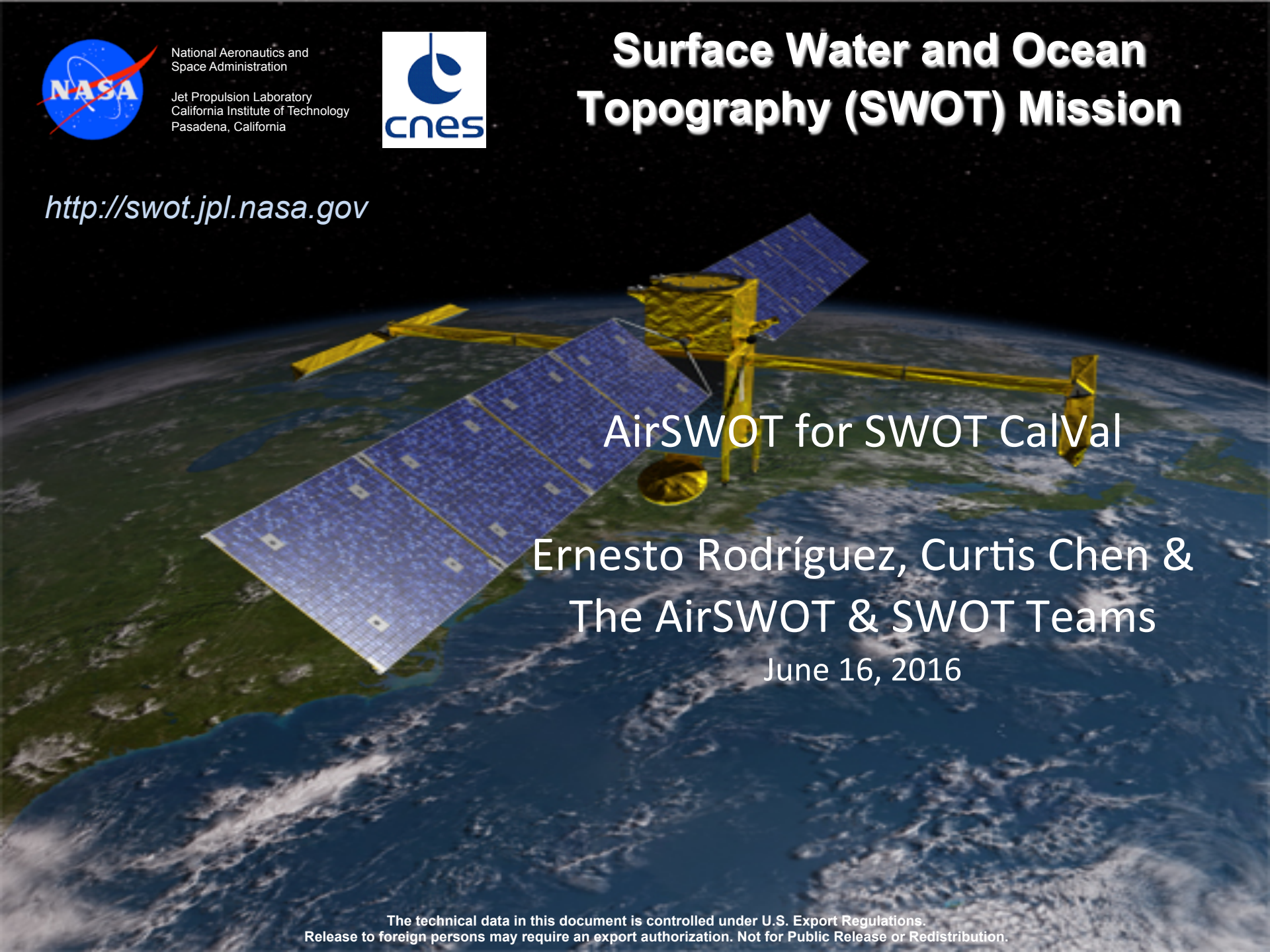
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission

http://swot.jpl.nasa.gov



AirSWOT for SWOT CalVal

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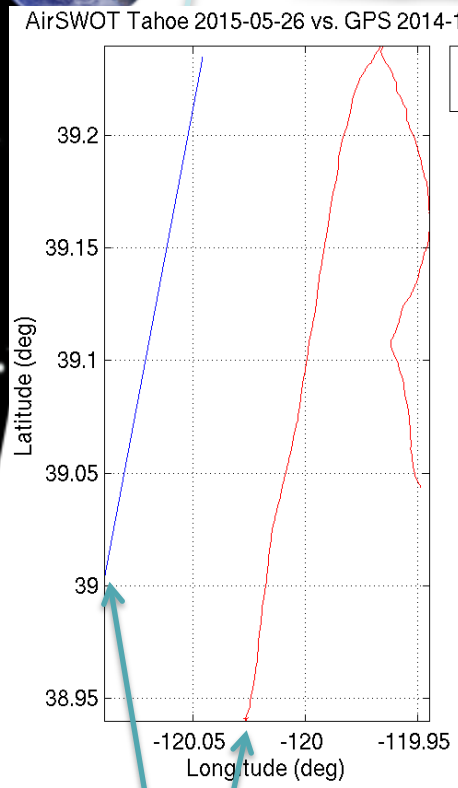
Challenges & Opportunities

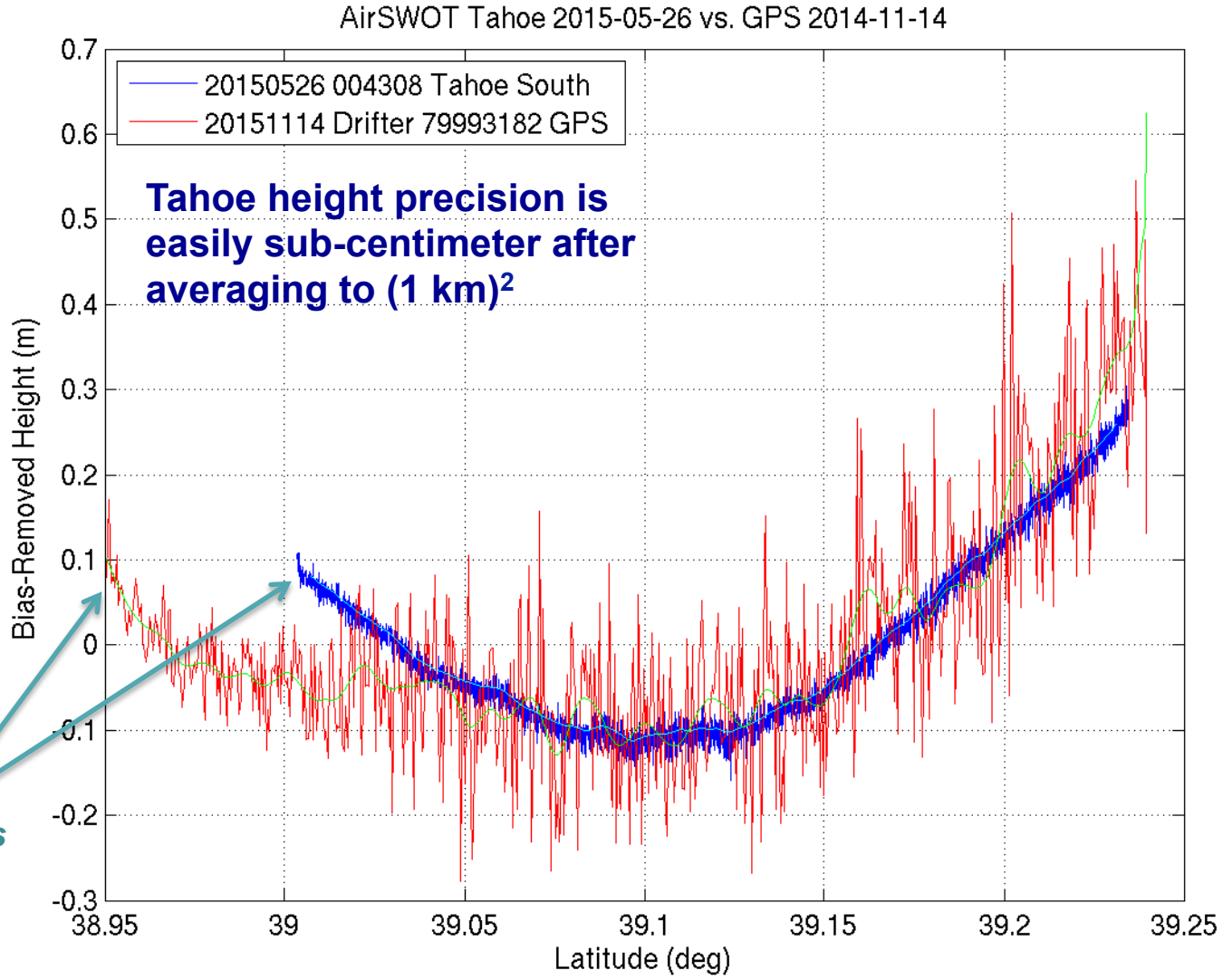
- The AirSWOT error budget has error components due to waves that can make the measurement challenging
  - **White noise**: not discussed here as it does not impact long wavelengths
  - **Surfboard effect**: effect on the range-direction spectra, not on the long-wavelength along-track spectrum
  - **Location shifts due to radial velocity:**
    - Height biases due to mean velocity shifts (accounted for in SWOT error budget)
    - Spectral distortions due to wave bunching
  - **Height biases due to iso-range/iso-phase mismatch**
    - Surface scattering decorrelation induced by wave motion can cause a wave dependent bias for high-resolution SAR systems (e.g., AirSWOT)
    - Effect accounted for in low-resolution SWOT error budget (waves have little impact)
  - **Non-uniform brightness modulation: EM bias**
    - Common with SWOT
- AirSWOT provides the only means to assess certain parts of the SWOT error budget
  - Radar cross section validation
  - Surfboard and wave bunching effects
  - Doppler impacts on SWOT via measurement of Doppler through ATI

Validation of Error Signal

- AirSWOT has shown good performance over situations where the SWH is small
- These situations are often present in large lakes, which exhibit moderate fetch are not affected by swell
- In these situations, AirSWOT could clearly validate many parts of the SWOT high frequency ***error*** characteristics not coupled to SWH
- Determining the SWOT noise characteristics at high frequency (not only white noise, but correlated noise in the frequency bands between 30km and 1km) is best done in the absence of signal (boring oceanography) not when the signal is interesting.

Tahoe Along-Track Height Profile





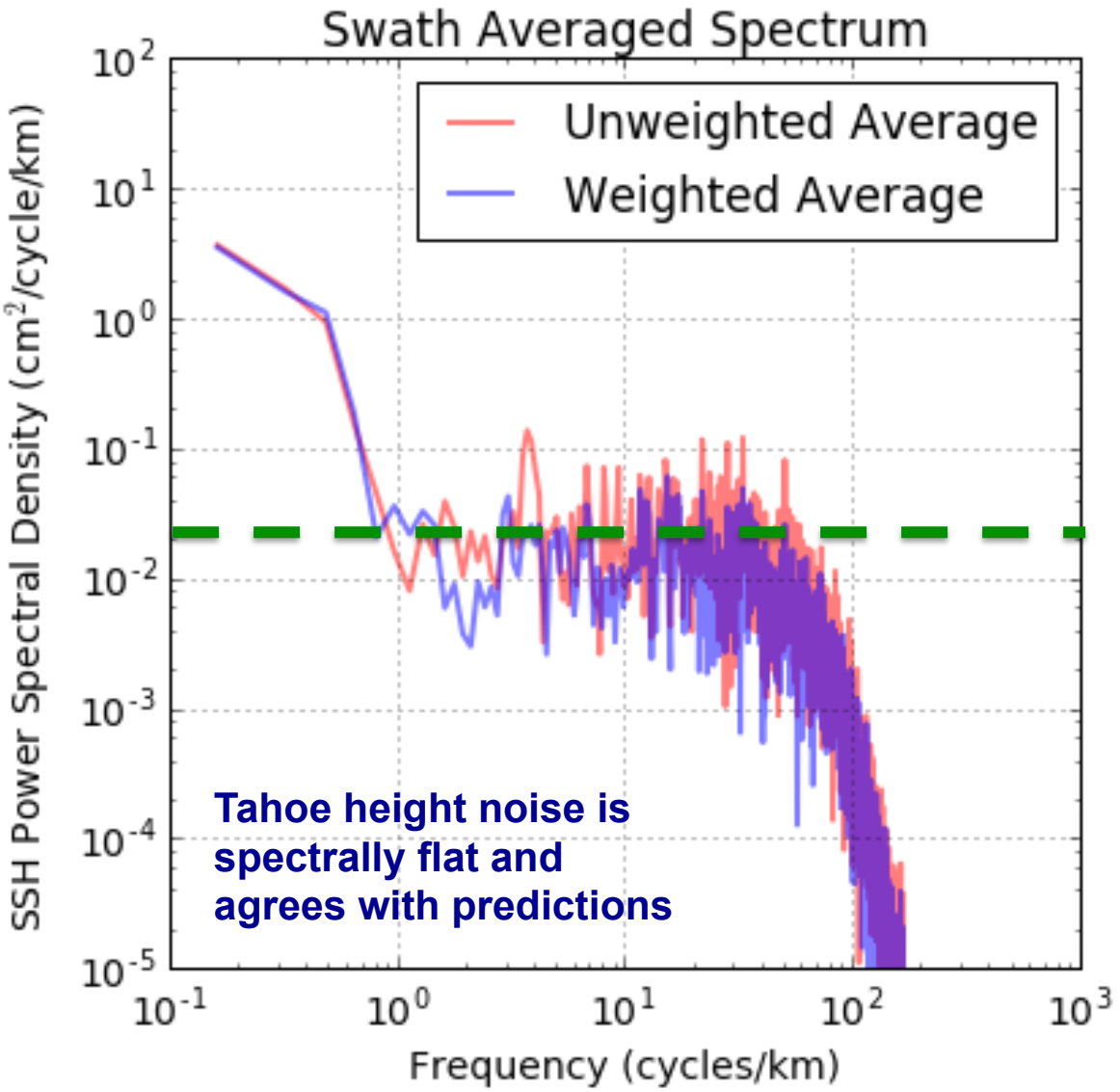
AirSWOT and GPS tracks are spatially offset from one another

Lake Tahoe Anomaly Spectra

Noise floor PSD <0.02cm^2/cycle/km

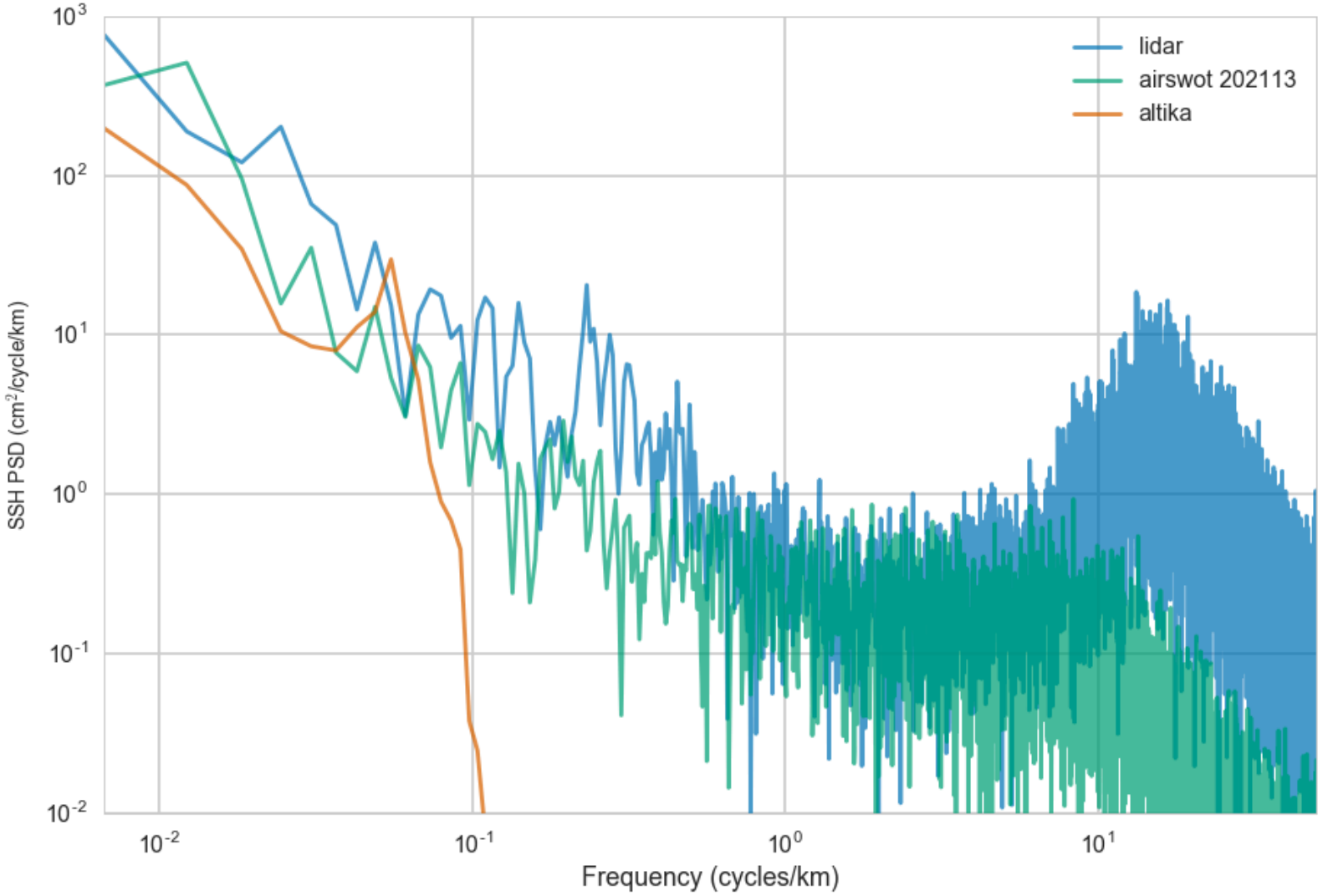
Integrating from 0.01 km this results in an expected standard deviation of 1.4cm

Averaging to 1km will result in height noise of 0.14 cm



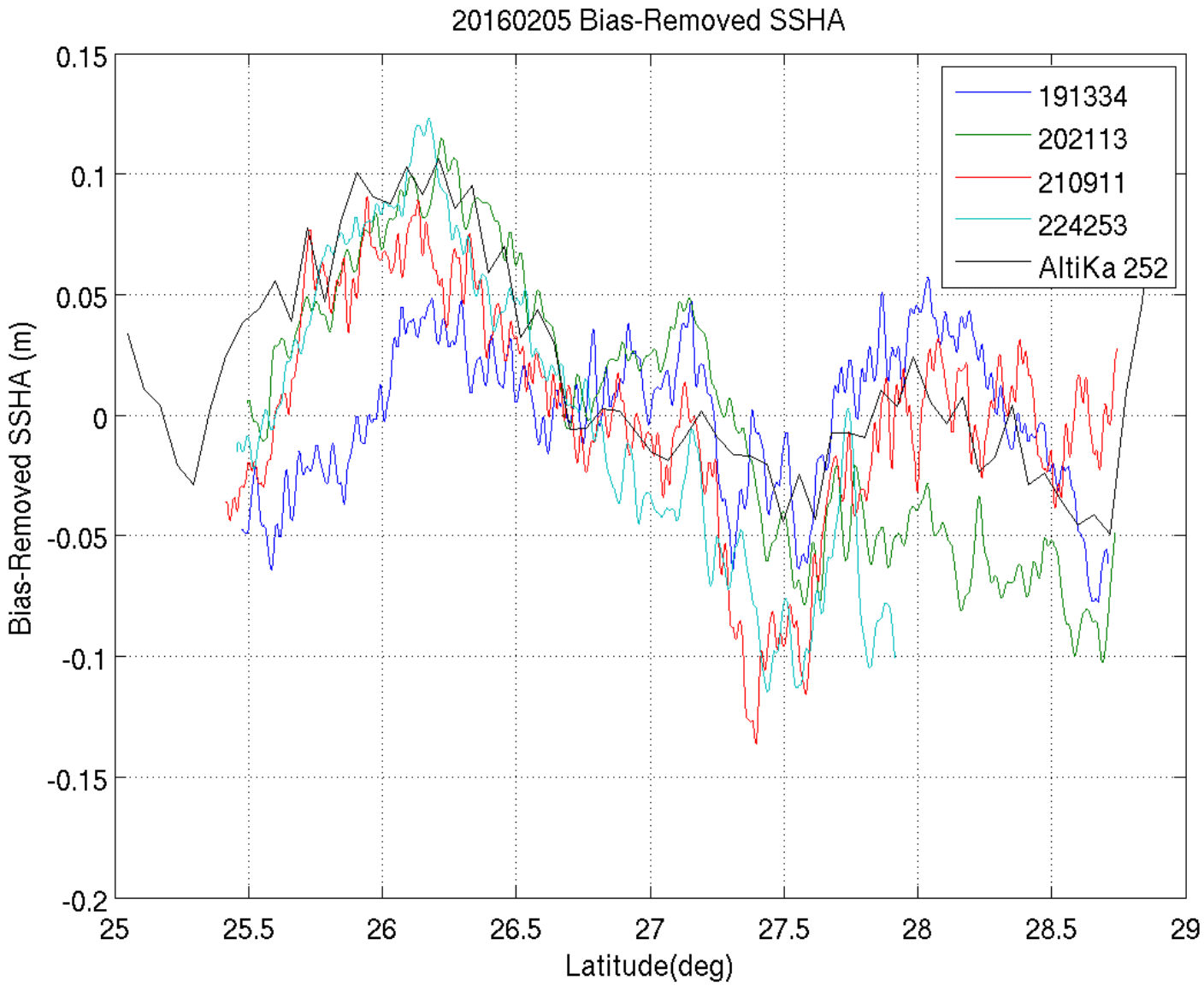
AirSWOT Performance status in the presence of waves

CARTHE Feb 5, Along-track Spectra

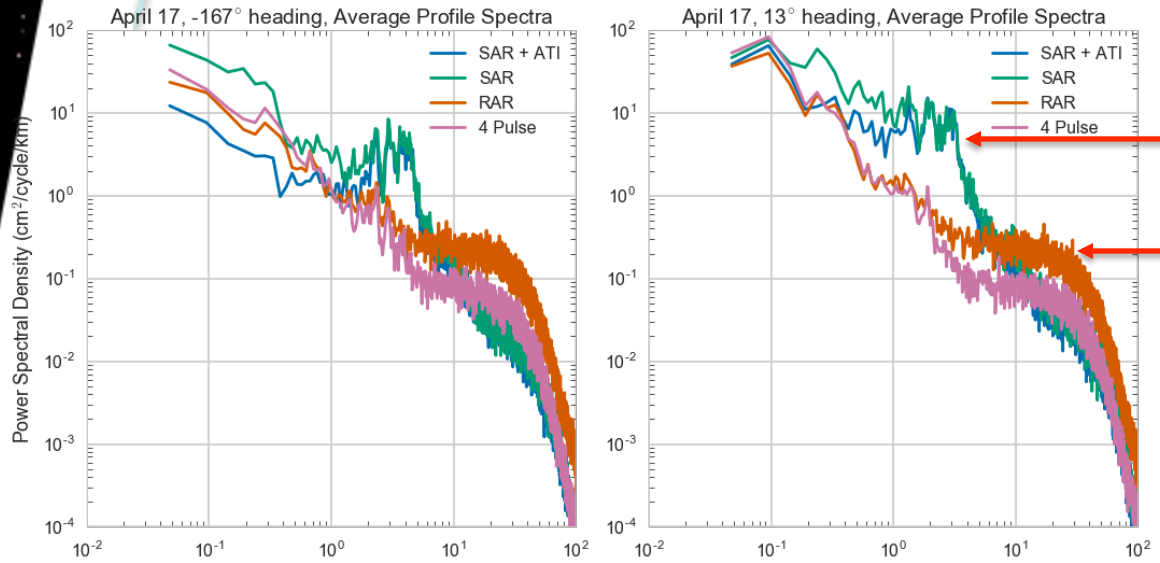


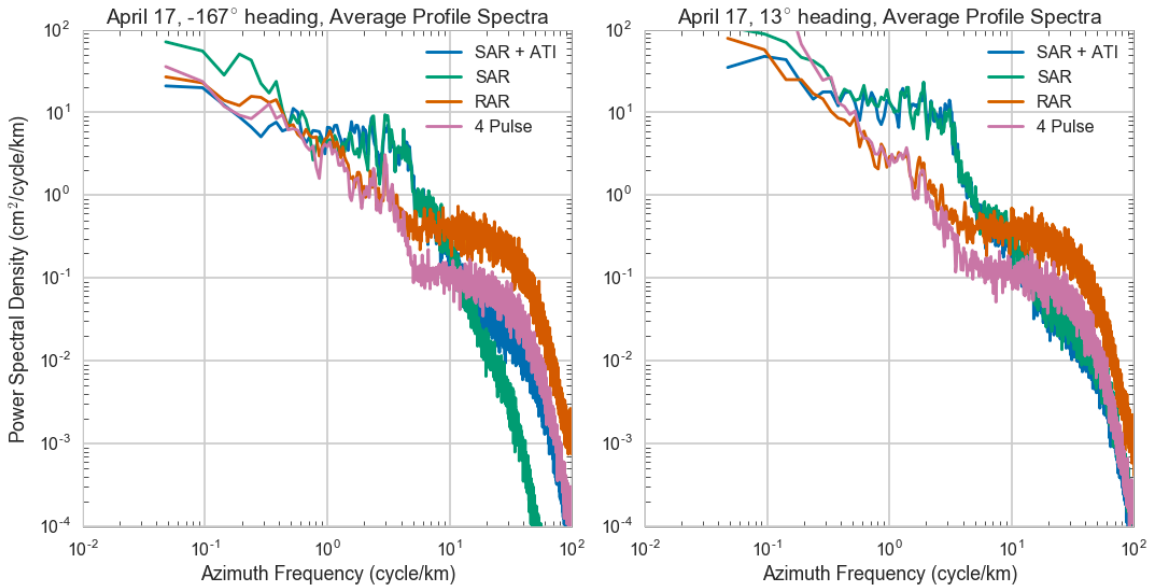
MASS data courtesy of K. Melville, L. Lenain, Scripps

Altika Comparison



Monterey, High Wave Swell Conditions
1D Spectra for SAR and RAR





SAR data shows spectral hump

RAR data shows no spectral hump

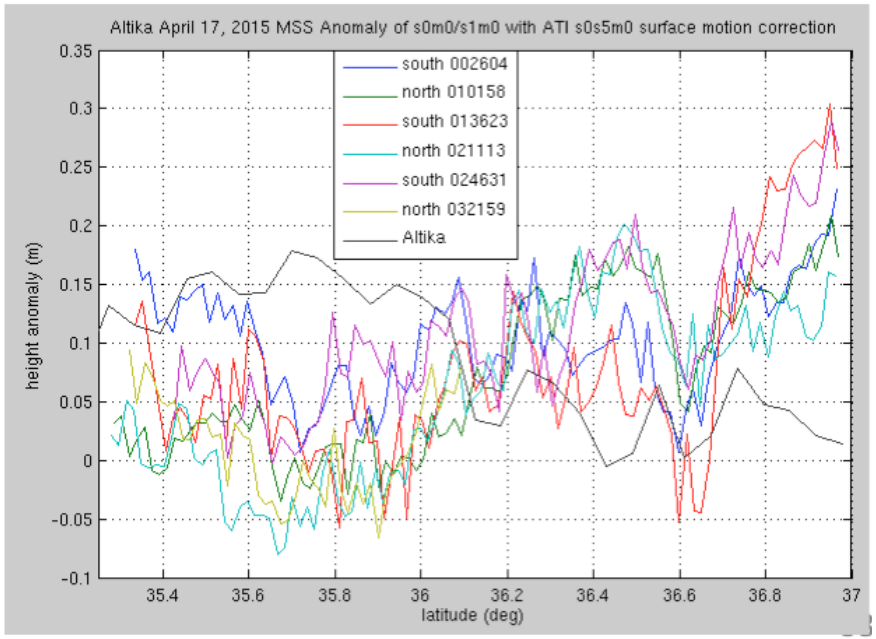
SAR & RAR exhibit similar long-wavelength behavior

South Lines

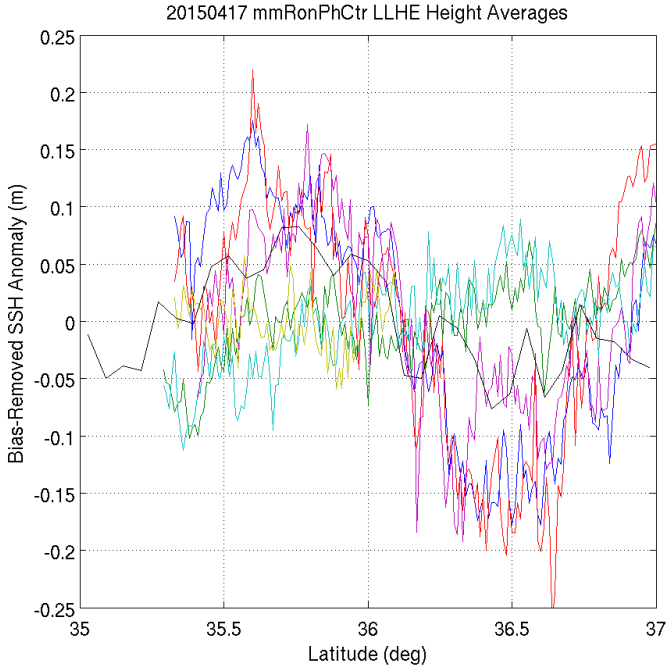
North Lines

Cross-Track Variations in MSS Strongly Correlated with Long-Wavelength Errors

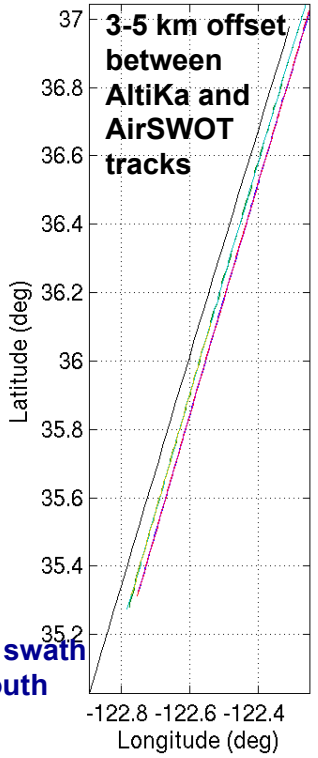
- Clustering of long-wavelength errors with flight direction is introduced when MSS is subtracted from SSH to get SSHA
- If MSS is correct, AirSWOT observations of SSHA are still unexplained; but if MSS is incorrect, MSS errors explain clustering
- Residual disagreement between AirSWOT and AltiKa remains



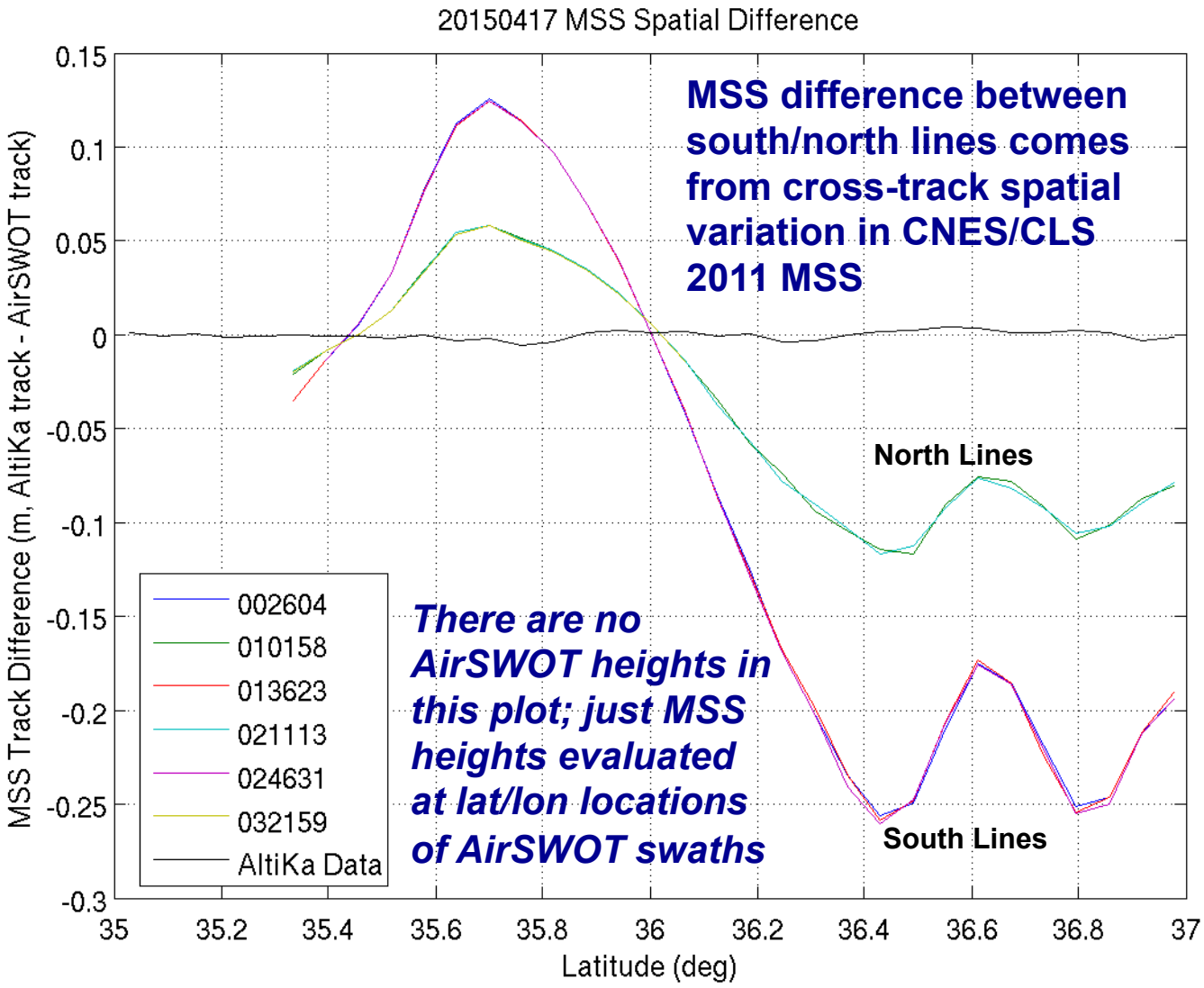
AirSWOT SSHA after subtracting common MSS of AltiKa track, not actual locations of AirSWOT swaths: Better overall clustering



AirSWOT SSHA after subtracting MSS at AirSWOT swath locations, which are offset in cross track: North/south clustering introduced, wider overall spread



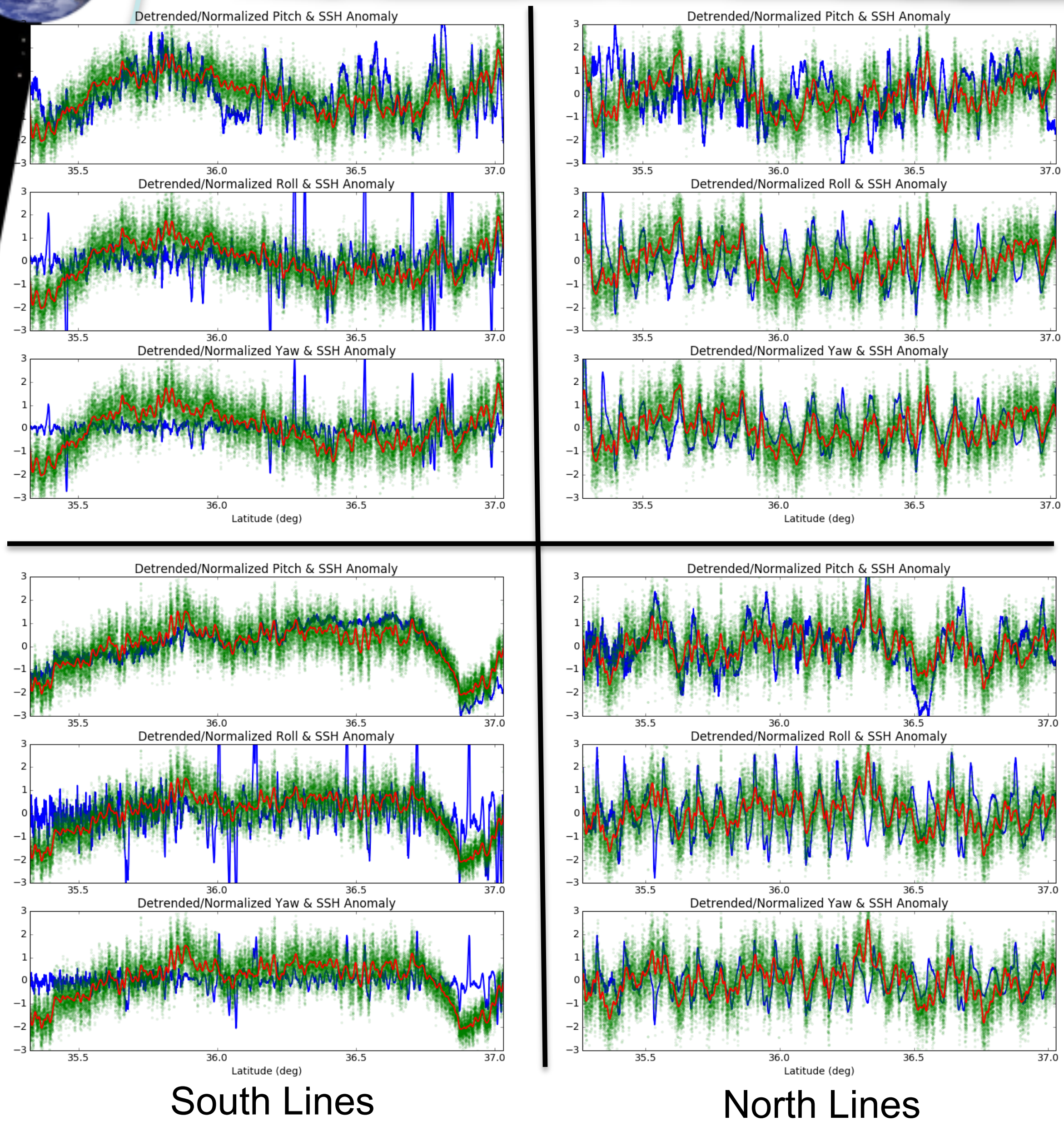
MSS Height Spatial Difference



Comparison of MSS at AirSWOT swath locations (not nadir tracks) to MSS at AltiKa nadir track

Difference between CNES/CLS 2011 MSS at AltiKa track and MSS from AltiKa data is very small (black curve), as expected

Real Aperture Attitude & SSH Anomaly



SSH Anomaly and attitude variables are detrended and scaled to unit variance so that they can be compared.

1 panel/flight line

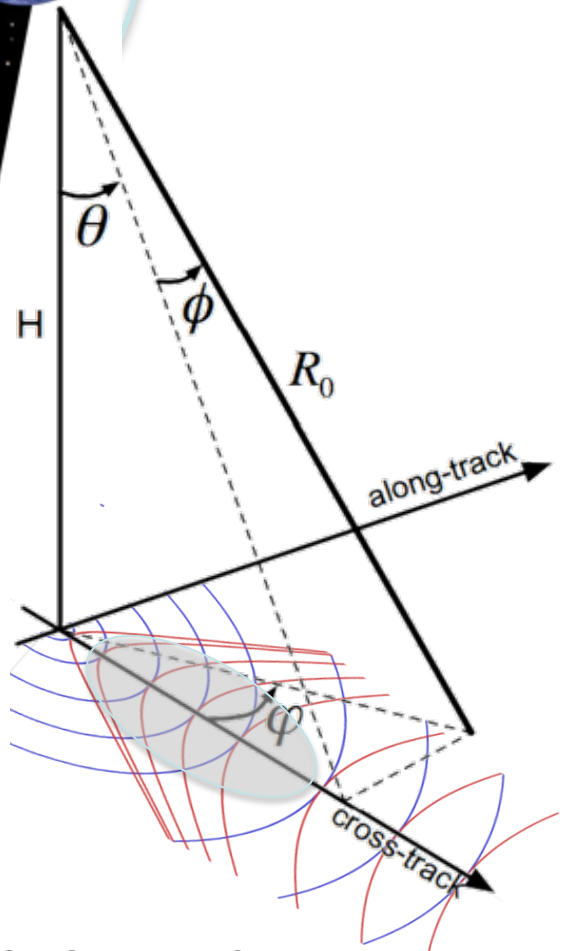
Blue line: attitude history for pitch (top), roll (middle), yaw (bottom).

Green dots: SSH anomaly unfiltered.

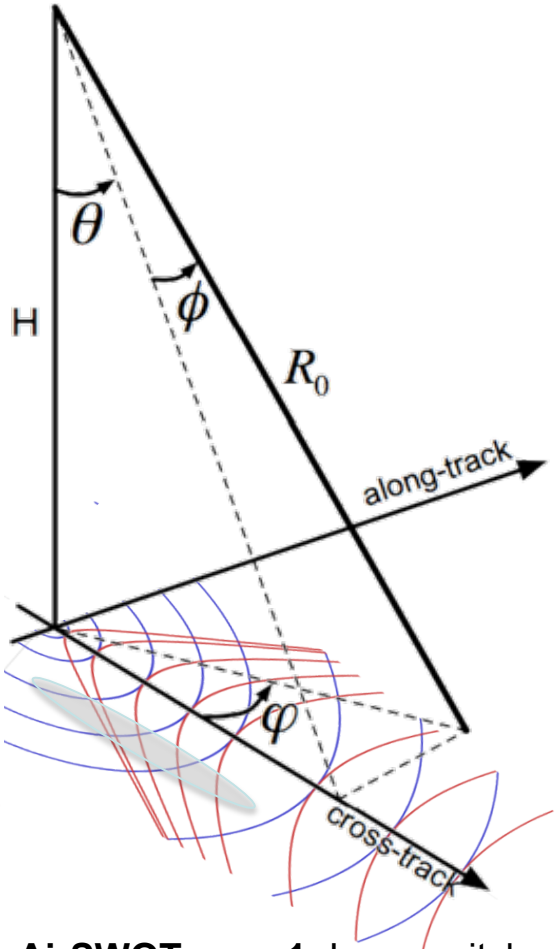
Red line: SSH anomaly low-pass filtered.

Notice: South lines exhibit clear pitch dependence. North lines also follow roll & yaw.

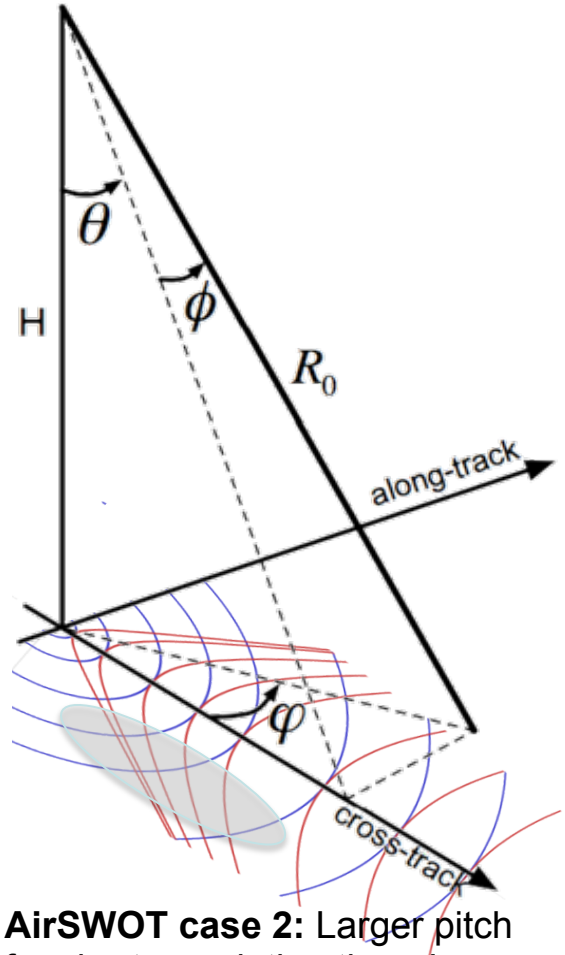
Iso-Range, Iso-Phase Effects



SWOT case: Small pitch. Iso-range/Iso-phase mismatch occurs at the lowest change in the curves. Antenna azimuth footprint ~250m. Small effect. Corrected in SWOT processing.



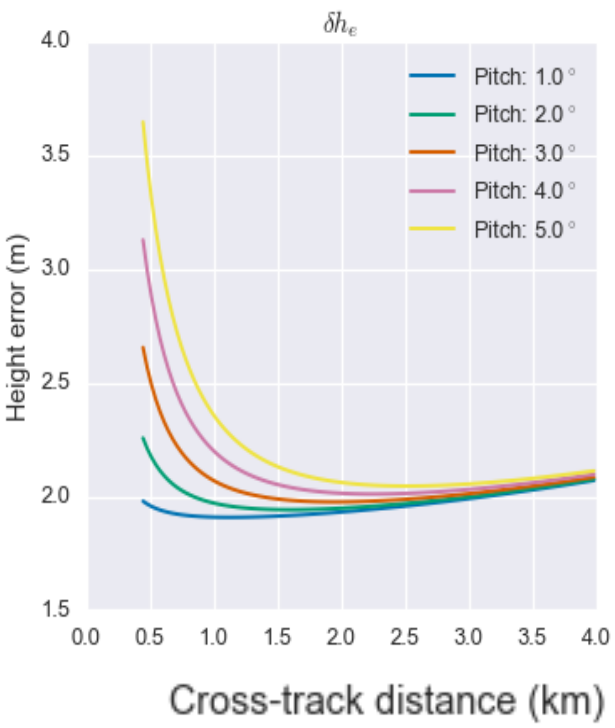
AirSWOT case 1: Larger pitch for long correlation time. Iso-range/Iso-phase mismatch occurs at higher change in the curves. Antenna azimuth footprint ~10m. Small effect.



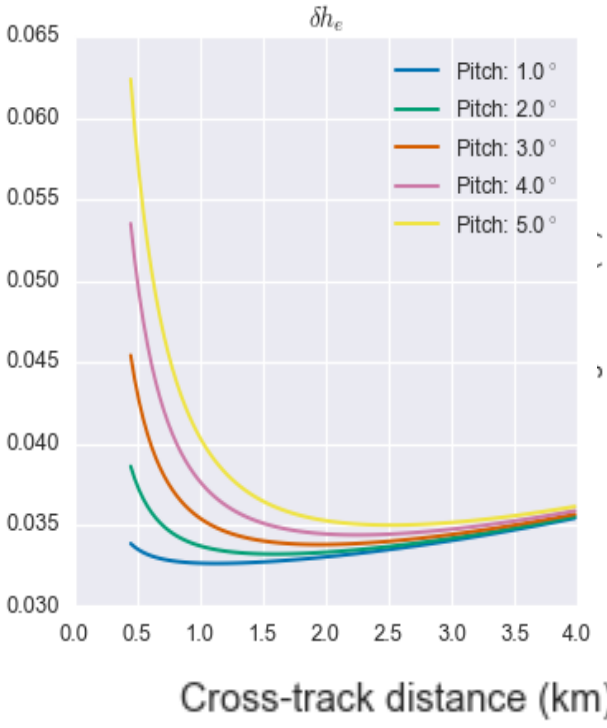
AirSWOT case 2: Larger pitch for short correlation time. Iso-range/Iso-phase mismatch occurs at higher change in the curves. Antenna azimuth footprint ~100m but not exactly known. Larger effect.

Error Sensitivity to Pitch

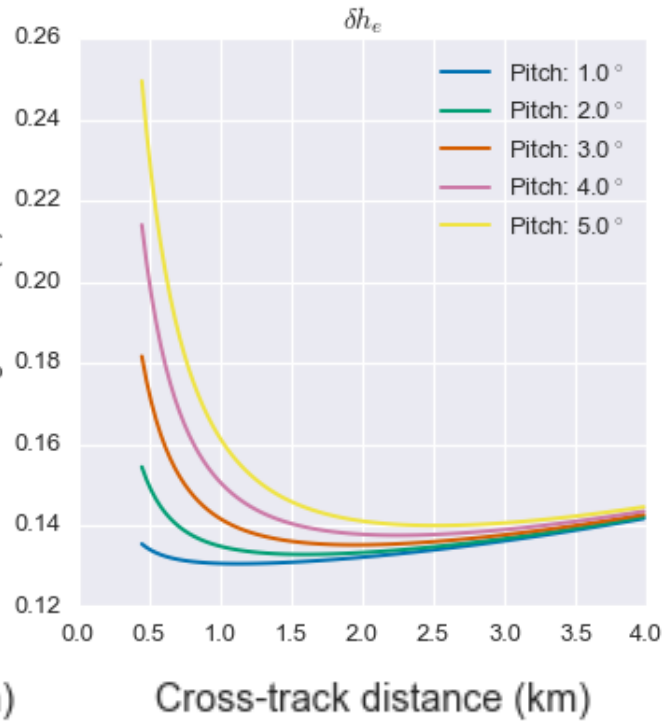
RAR



SAR 10 msec



SAR 5 msec



Summary

- AirSWOT currently seems to be a viable platform for validating the SWOT error budget synoptically across-track for regions where there is small wave impact
  - Validating in the absence of ocean signal has many benefits for examining instrument errors
  - However, there are geophysical errors and errors where wave characteristics are important where, at this point, AirSWOT is not meeting the validation standards.
- The AirSWOT team is examining multiple alternatives for improving the performance of AirSWOT in the presence of waves
  - Real aperture mode
    - ♦ Need to account for attitude effects. Processing software modifications are underway to produce attitude corrected AirSWOT products.
  - Use of along-track interferometer (ATI) data
    - ♦ Directly measures wave radial velocity and could be extremely useful for assessing SWOT sensitivity to wave motion effects
    - ♦ Corrections using ATI data are also being implemented to remove the wave effects. The ability to correct for these effects may be limited to wave conditions (SWH and wave direction) where wave bunching is invertible